

# Fault Diagnosis of Embedded Software using Program Spectra\*

Peter Zoetewij<sup>1</sup>   Rui Abreu<sup>1</sup>   Rob Golsteijn<sup>2</sup>  
Arjan J.C. van Gemund<sup>1</sup>

<sup>1</sup>Embedded Software Lab,  
Software Engineering Research Group, TU Delft  
{p.zoetewij,r.f.abreu,a.j.c.vangemund}@tudelft.nl

<sup>2</sup>NXP  
rob.golsteijn@nxp.com

In this paper we present a technique to automatically diagnose errors detected during software testing. With diagnosis we mean localization of the fault that causes these errors. Strictly speaking, this belongs to the debugging phase, rather than to the testing phase of the software development cycle, but the technique is well suited for integration with (automated) testing, and enhances the information that can be extracted from this phase.

We assume that testing involves a number of different runs (or transactions, usage scenario's, etc.) of the same software. Per run, we record a so-called *program spectrum* (see, e.g., [2]). The particular form of program spectrum that we are interested in is an array of Boolean flags that tells us which parts of the software were active during a run. This can be measured at different levels of granularity, for example, at component, class, or function level, but also at the level of individual statements, or blocks of code. Together, the program spectra for a series of test runs form a binary matrix, whose row vectors correspond to the runs, and whose column vectors tell us in which runs a particular part of the software was active (see Figure 1).

During testing, errors are detected in some of the runs. This information constitutes another column vector, the error vector, which can be seen as to correspond to a hypothetical part of the software that is responsible for the detected errors. The assumption is that the actual parts of the software whose column vectors resemble the error vector most, have a high probability of containing the fault. Basic data clustering techniques can be applied to

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## About the Authors

**Peter Zoetewey** works in the Software Engineering Research Group at Delft University of Technology. He holds an MSc. from Delft University of Technology, and a PhD. from the University of Amsterdam, both in computer science. Before his PhD., Peter worked for several years as a software engineer for Logica (now LogicaCMG), mainly on software for the oil industry.

**Rui Abreu** is a PhD. student at the Embedded Software Lab within the Software Engineering Research Group at Delft University of Technology. He holds an MSc. in Computer Science and Systems Engineering from Minho University, Portugal. Through his thesis work at Siemens R&D Porto, and professional internship at Philips Research, he acquired industrial experience in the area of embedded systems.

**Rob Golsteijn** holds an MSc. in Computing Science from Eindhoven University of Technology and completed the two years' post-graduate Software Technology program from the Stan Ackermans Institute. Rob now works for NXP, formerly known as Philips Semiconductors, and has experience in embedded software development of television platforms and products. Rob is currently working as a member of an industrial research project focusing on reliability of resource-constrained consumer devices.

**Arjan J.C. van Gemund** holds a BSc. in physics, and an MSc. (cum laude) and PhD. (cum laude) in computer science, all from Delft University of Technology. He has held positions at DSM and TNO, and currently serves as a full professor at the Electrical Engineering, Mathematics, and Computer Science Faculty of Delft University of Technology, heading the Embedded Software Lab within the Software Engineering Research Group.